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# 1. INTRODUCTION

The Consultants are planning to carry out several types of survey and investigations for the project area to collect available information about the existing condition of the project and familiarize the design team with all the project components. The collected data, survey and investigation information will be the basis of different studies to support the design of the project.

The list of main surveys to be carried out is as follows:

- Traffic Surveys
- Geotechnical Investigations
- Topographic Survey
- Structures Condition Survey of Jam Sadiq Bridge
- Utilities Survey
- Assessment of Existing Pavement

The purpose of this report is to present the proposed methodology for the different types of surveys listed above, for SMTA's review and approval.

# 2. TRAFFIC SURVEYS

## 2.1 SURVEY METHOLODOGY

The Consultants have planned to carry out surveys at different locations along the project, based on the review of the preliminary engineering design and available data. These surveys include classified Turning Movement Counts "TMC", Pedestrian Surveys, and Parking Surveys.

Some of these surveys will be performed through video camera, therefore, the Consultants intend to hire a Traffic Survey Specialist for conducting field work and data processing.

## 2.2 SITE RECONNAISSANCE SURVEY

Reconnaissance surveys were carried out to gather preliminary information of proposed survey locations. As a result, proper traffic survey mounting locations and interview locations were selected to ensure uninterrupted traffic surveys. Special consideration was made for the selection of the interview site selection, as it will be made only on stoppage points, where surveyor can safely ask questions.

## 03 CLASSIFIED TURNING MOVEMENT COUNTS

Classified Turning Movement Counts (TMCs) will be carried out at six (6) locations through Video Cameras during 16 continuous hours from 7:00am to 11:00pm for two (2) days (1 typical weekday and 1 weekend) and will be recorded over 15-minute time intervals. These surveys will be carried out during the period Tuesday to Thursday for weekdays. No surveys will be carried out on Monday or Friday. Similarly, no survey activity will take place on public holidays or the day before or after a public holiday. The Government of Pakistan has announced that schools shall be open effective October 11, 2021; hence survey activities have been planned to start after October 11, 2021 in order to capture most traffic.

Based on the reconnaissance visits of proposed survey locations to gather preliminary information and to finalize camera mounting locations, special type of cameras will be placed on the final locations. These cameras will have backup batteries, charger, invertors, regulator box, heat sink, IP65 camera housing, tripod with balancer and waterproof protective bag. These purpose-based design kits have an ability to work continuously for 48 hours in extreme weather on its own. The recorded videos will then be processed by the enumerators in the supervision of traffic engineers.

Traffic movement count in each direction will be processed using specialized software application and network-based database to maintain the accuracy. Further, to ensure the quality and authenticity of data, randomly selected 15 minutes out of every hour will be cross checked by the processing team leader to maintain accuracy and eliminate human errors. Each rejected video count will again be sent to the enumerator for processing.

The proposed locations for the TMCs are listed below and shown in **Figure 1**.

- TMC – 1 Tariq Road
- TMC – 2 KPT Roundabout
- TMC – 3 Bilal Chowrangi
- TMC – 4 Herbion Roundabout / Shan Chowrangi
- TMC – 5 Dawood Chowrangi
- TMC – 6 Vita Chowrangi

Apart from the traffic counts, the number of lanes, lane widths, traffic directions, posted speed, junction type and shoulder / median condition will also be recorded.

The TMCs will determine the variation in turning movements at the traffic junctions (roundabouts and intersections) for each vehicle class. The classifications for the traffic are given below:

- Motorcycle
- Car/Taxi
- Van/Pickup
- Rickshaw / Qingchi
- Coasters / Coach / Mini Buses
- Large Buses
- 2, 3, 4 and 5 Axle trucks
- Other Machinery

## 2.4 PARKING SURVEYS

Parking surveys will be carried out by recording license plate numbers of incoming and outgoing vehicles at gated entrance of parking areas along with quantification of number of parking stalls and number of already occupied parking slots at the start time of survey. These license plate numbers will then be matched to find the duration of parking of each vehicle that enters or exits during study time, in order to determine the parking turnover which in turn will assist in the finalization of parking requirements.

Surveys will be conducted at eight (08) locations for 2 days (1 typical weekday and 1 weekend) during three continuous hours in the morning (7am to 10am), afternoon (12pm to 3pm) and evening peak (5pm to 8pm) periods. For each parking lot, the license plate number will be recorded during the survey period over 15-minutes interval.

Parking surveys will be accompanied by the interview of drivers who are using the parking facility. The drivers to be interviewed will be randomly selected on site by the traffic surveyors. This activity will assist in identification of characteristics of the parking users such as the parking purpose, frequency per week, the origin and destination of the trip, the waiting time, the proximity of the parking lot to the destination of the trip, etc.

Following are the typical questions to be asked during the interviews:

- parking purpose,
- frequency per week,
- origin and destination of the trip,
- waiting time,
- proximity of the parking lot to the destination of the trip.

The Locations for the Parking Surveys are listed below, and also shown in **Figure 1**.

- Parking Survey – 1 NESPAK Office Building
- Parking Survey – 2 Near Khayaban-e-Ittehad / Korangi Road Intersection
- Parking Survey – 3 Imtiaz Supermarket Parking
- Parking Survey – 4 Brooks Chowrangi
- Parking Survey – 5 Near Brookes Pharma
- Parking Survey – 6 Near Artistic Denim Mills
- Parking Survey – 7 Murtaza Chowrangi
- Parking Survey – 8 Indus Chowrangi

## 2.5 PEDESTRIAN SURVEYS

Pedestrian surveys will be carried out using the video recording-based method. Cameras will be mounted at specific locations to have a clear view of pedestrian crossings. Moreover, where the video recording will not be feasible, manual counting procedure will be adopted along with traffic surveyors / enumerators.

Pedestrian surveys will be conducted at ten (10) locations for 2 days (1 typical weekday and 1 weekend) during three continuous hours in the morning (7am to 10am), afternoon (12pm to 3pm) and evening peak (5pm to 8pm) over 5-minute interval to determine the pedestrian flow direction and volume.

The Locations for the Pedestrian Surveys are listed below and shown in **Figure 1**.

- Pedestrian Survey – 1 Future Mor
- Pedestrian Survey – 2 National Medical Center (NMC)
- Pedestrian Survey – 3 Near Masjid Tooba
- Pedestrian Survey – 4 Near Khayaban-e-Ittehad / Korangi Road Intersection
- Pedestrian Survey – 5 Near Suzuki South
- Pedestrian Survey – 6 Near Toyota Defence Motors
- Pedestrian Survey – 7 Murtaza Chowrangi
- Pedestrian Survey – 8 Indus Chowrangi
- Pedestrian Survey – 9 KPT Roundabout
- Pedestrian Survey – 10 Sharah-e-Faisal (FTC)

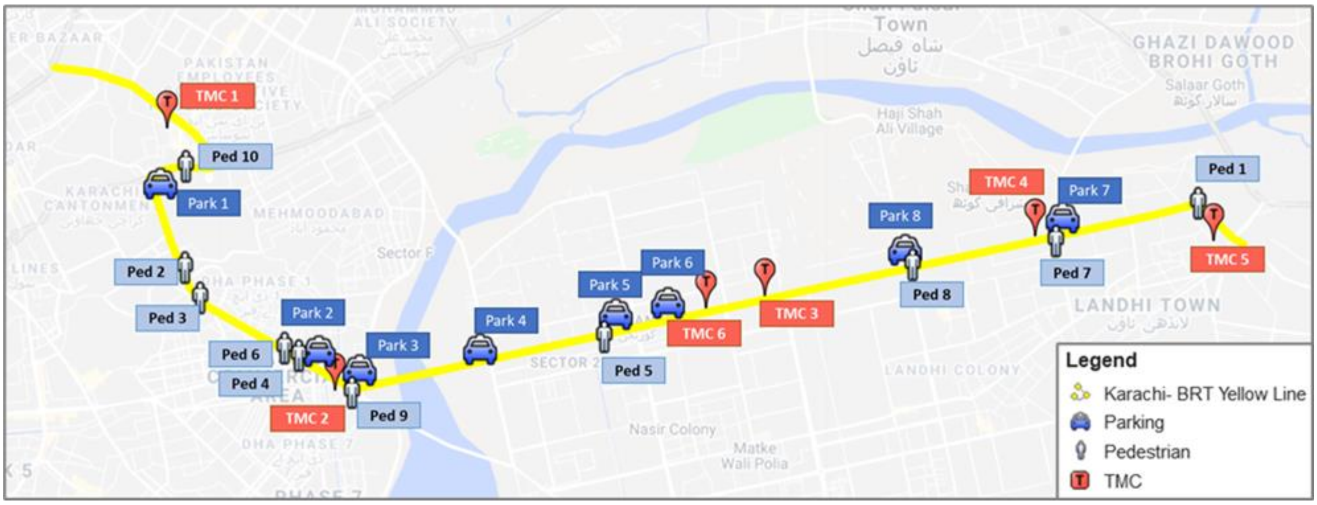


Figure 1: Traffic Survey Location Plan

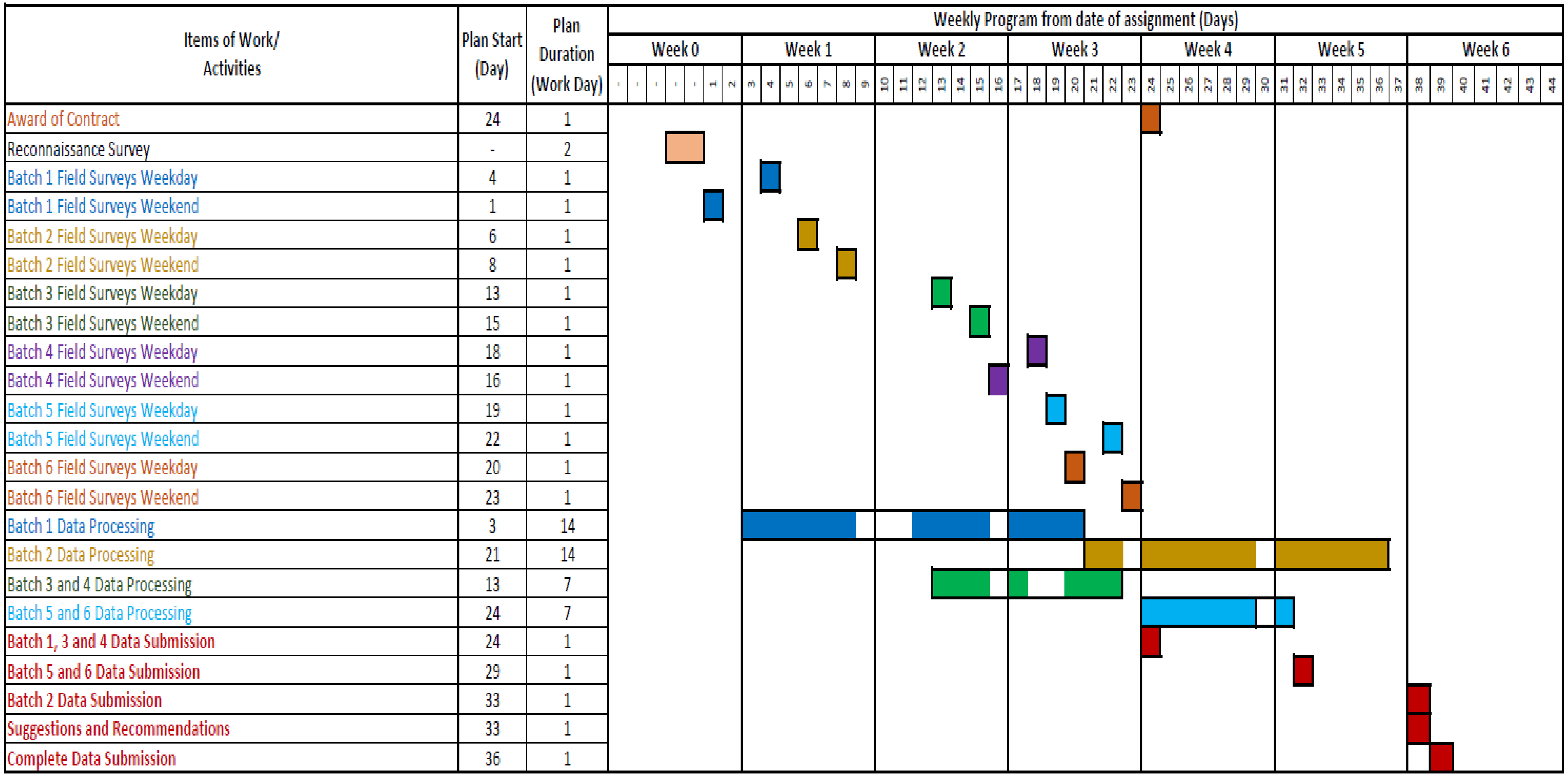
## 2.6 TRAFFIC SURVEY SCHEDULE

The proposed schedule for the traffic surveys is summarized in Figure 2, while the detail of each batch is listed in Table 1.

**Table 1: Traffic Survey Schedule**

| S. No. | Batch No. | Location Code |
|---|---|---|
| **1** | 1 | TMC 4 - Herbion Roundabout |
| **2** | | TMC 5 - Dawood Chowrangi |
| **3** | | TMC 6 - Vita Chowrangi |
| **4** | | Pedestrian 7 Murtaza Chowrangi |
| **5** | 2 | TMC 1 - Tariq Road |
| **6** | | TMC 2 - KPT Roundabout |
| **7** | | TMC 3 - Bilal Chowrangi |
| **8** | | Pedestrian 9 KPT Roundabout |
| **9** | 3 | Pedestrian 1 Future Mor via Video Recording |
| **10** | | Pedestrian 8 Indus Chowrangi Video Recording |
| **11** | | Parking 8 Indus Chowrangi |
| **12** | | Parking 7 Murtaza Chowrangi |
| **13** | 4 | Pedestrian 3 Old Korangi Road near Tooba Masjid |
| **14** | | Pedestrian 4 Near Sunset Boulevard |
| **15** | | Pedestrian 6 Near Sunset Boulevard |
| **16** | | Pedestrian 10 Shahrah e Faisal near Sindhi Muslim |
| **17** | 5 | Pedestrian 2 NMC |
| **18** | | Parking 1 NESPAK Office Building |
| **19** | | Parking 2 Royal Defence Mall |
| **20** | | Parking 3 Imtiaz |
| **21** | 6 | Parking 5 Near Brookes Pharma |
| **22** | | Parking 6 Near Artistic Denim Mills |
| **23** | | Parking 4 Sanofi Aventis |
| **24** | | Pedestrian 5 Near Soorty Enterprise |

Necessary permissions / assistance to conduct surveys will be needed from various stakeholders, for which coordination is requested from the Client in order to abide by the proposed schedule.



| Items of Work/ Activities | Plan Start (Day) | Plan Duration (Work Day) |
|---|---|---|
| Award of Contract | 24 | 1 |
| Reconnaissance Survey | - | 2 |
| Batch 1 Field Surveys Weekday | 4 | 1 |
| Batch 1 Field Surveys Weekend | 1 | 1 |
| Batch 2 Field Surveys Weekday | 6 | 1 |
| Batch 2 Field Surveys Weekend | 8 | 1 |
| Batch 3 Field Surveys Weekday | 13 | 1 |
| Batch 3 Field Surveys Weekend | 15 | 1 |
| Batch 4 Field Surveys Weekday | 18 | 1 |
| Batch 4 Field Surveys Weekend | 16 | 1 |
| Batch 5 Field Surveys Weekday | 19 | 1 |
| Batch 5 Field Surveys Weekend | 22 | 1 |
| Batch 6 Field Surveys Weekday | 20 | 1 |
| Batch 6 Field Surveys Weekend | 23 | 1 |
| Batch 1 Data Processing | 3 | 14 |
| Batch 2 Data Processing | 21 | 14 |
| Batch 3 and 4 Data Processing | 13 | 7 |
| Batch 5 and 6 Data Processing | 24 | 7 |
| Batch 1, 3 and 4 Data Submission | 24 | 1 |
| Batch 5 and 6 Data Submission | 29 | 1 |
| Batch 2 Data Submission | 33 | 1 |
| Suggestions and Recommendations | 33 | 1 |
| Complete Data Submission | 36 | 1 |

**Figure.2: Tentative Traffic Survey Schedule**

# 3. GEOTECHNICAL INVESTIGATIONS

## 3.1 INTRODUCTION

The Consultants have gathered available / existing data and previous reports related to geotechnical aspects, like subsurface soil profiles, boreholes logs, test pit logs, field and laboratory testing data. The collected data have been reviewed in the light of available recent literature and project requirements to assess the geotechnical conditions of the area.

## 3.2 SITE RECONNAISSANCE SURVEY

Field reconnaissance visits will be undertaken, which will help to formulate the needed geotechnical investigations and further studies. The site visits will all the Consultants to perceive the following features of the project area:

- General terrain and topography
- General soil/rock conditions
- Existing structures condition
- Extent of needed additional geotechnical investigations

The review and analysis of existing data, coupled with the findings of the reconnaissance visits, will help in finalizing the programme of geotechnical investigations.

## 3.3 PROGRAMME OF GEOTECHNICAL INVESTIGATIONS

The geotechnical investigations will be carried out by specialized drilling contractor(s) under the full-time supervision of the Consultants’ staff.

Geotechnical investigations include drilling of boreholes, excavation of test pits, rock coring, field tests, sampling and laboratory testing. The field investigations envisaged at the selected locations will be carried out in accordance with the ASTM/BS or equivalent Standards.

The proposed subsurface geotechnical investigations are briefly discussed below:

### 3.3.1 Field Investigations:

#### *A - Drilling of Boreholes*

Boreholes, up to a maximum depth of 40 m below NSL, will be executed at proposed structure locations. Straight rotary drilling / percussion boring method will be used for execution of boreholes.

The frequency of the boreholes will be different based on the type of the structure along the project, and are as follows:

- Flyover Structure – 3 boreholes
- Closed Underpass Structure – 1 borehole
- Open Underpass Structure – 2 boreholes (i.e. 1 borehole at each side of the closed underpass structure)
- Elevated U-turn Structure – 3 boreholes
- Kala Pull Bridge – 3 boreholes
- Underground Station – 1 borehole
- At-Grade Station – 1 borehole
- Depot Area – 2 boreholes

#### *B - Excavation of Test Pits*

Test pits, up to a depth of 2 m below NSL, will be excavated along the alignment of Yellow BRT line. The primary objective of the test pits will be to evaluate the conditions of existing road(s) and carrying out the required field tests including Field density tests for each existing unbound layer (Subgrade, Aggregate Subbase layer, Aggregate Base Course layer, etc..), and measuring the California Bearing Ratio (CBR) for these layers. A total of one hundred and seventy-five (175) test pits are proposed, detailed as follows:

- Fifty-Five (55) Test Pits for the main Corridor with 400m interval between test pits
- One Hundred eleven (111) Test Pits for the off corridor with 670m interval per test pit
- Nine (9) Test Pits for the two depots: three (3) for depot one, and six (6) for depot two

#### *C - Field Tests*

The following field tests will be performed in boreholes and test pits during the course of investigations:

- Permeability test / water pressure test / Packer test
- Standard Penetration test (ASTM D 1586)
- RQD assessment (where rock encountered)
- Field density test (ASTM D 1556)

#### *D - Collection of Disturbed, Undisturbed/Core Samples*

For a realistic evaluation of subsurface characteristics of soils/rock, samples (undisturbed, disturbed / core) from boreholes and test pits will be collected. The collected samples will be preserved, properly packed, marked and transported to an approved laboratory for requisite testing.

#### *E - Water Sampling*

Water samples, from the boreholes and test pits (where encountered), will be collected for testing and analysis.

### *F – Instrumentations*

Standpipe piezometers will be installed in selected boreholes to determine the fluctuations in the groundwater level. Monitoring of the piezometers will be done up to a period of three (03) months.

### 3.3.2 Laboratory Testing

The selected representative soil/rock and water samples collected during the execution of boreholes and test pits will be sent to an approved testing laboratory for the determination of physical, strength, and chemical properties of the materials, as per testing program prepared by the Consultants. The following laboratory testing on selected soil/rock/material samples will be carried out as per technical requirement:

- Grain Size Analysis
- Atterberg Limits
- Bulk and Dry Density
- Consolidation
- Unconfined Compressive Strength
- Uniaxial Compressive Strength
- Point Load Strength Index
- Modified AASHTO Compaction & CBR Testing
- Chemical Analysis of Water Samples i/e TDC, CI, SO4 & pH
- Chemical Analysis of Soil Samples

### 3.3.3 Daily Reports

The geotechnical investigation Contractor will submit a daily report including the following data:

- Name of the supervision engineer(s) at each working location
- Name of the drillers and contractor staff at each working location
- Time for the start and end of work
- Draft borehole and test pits logs
- Coordinate and ground level
- Results of field tests
- Monitoring data of piezometers (water depths)
- Suggested laboratory test programs
- Photos of the samples in sample boxes
- Photos of the rigs at the locations of the boreholes and trial pits.

## 3.4 TENTATIVE TIME SCHEDULE

A total of eight (8) weeks will be required to complete the field investigations. in addition, laboratory testing will take another three (3) weeks. Hence, a total of eleven (11) weeks will be required to complete the geotechnical investigations after mobilization of drilling Contractor at site.

# 4. TOPOGRAPHIC SURVEY

Necessary permissions to conduct the topographic survey will be needed from various stakeholders, for which coordination will be requested from the Client. Utility coordination will also be required in order to protect all underground utilities during the survey, and again SMTA's assistance is requested in this respect.

## 4.1 INTRODUCTION

The Consultants will carry out topographic survey for the project and will produce all necessary mapping for the whole components of the project, including the following:

- Site reconnaissance visit for first-hand knowledge of the terrain conditions
- Identification of the Survey of Pakistan benchmarks in the project vicinity
- Construction of the Survey Control Points
- Establishment of horizontal and vertical survey control points
- Topographic survey of yellow BRT route corridor, off-corridor roads, bus depots and drainage network in the vicinity of project area.
- Survey data Processing
- Preparation of the layouts and
- Topographical survey report

This task will be accomplished by deploying surveyors and survey helpers supervised by the Survey Team Leader.

## 4.2. SITE RECONNAISSANCE SURVEY

Various site reconnaissance survey visits have been conducted for the main corridor and off- corridor network to access the field conditions and general topography. Table 2 below shows the summary of routes included in the off-corridor network, while Figures 3 to 6 show reconnaissance survey on various roads.

**Table 2: Summary of Off-Corridor Network Routes**

| No | Description | Length (KM) | BRT Corridor (KM) | Overlapping Route | Overlapping Length (KM) | Net Length (KM) (excluding the BRT Corridor & Overlapping) |
|---|---|---|---|---|---|---|
| **1** | YL Direct 01 | 19.20 | 2.19 | - | 0.00 | 17.01 |
| **2** | YL Direct 02 | 20.65 | 10.40 | - | 0.00 | 10.25 |
| **3** | YL Direct 03 | 13.40 | 2.20 | Direct 3 & 5 | 0.58 | 10.62 |
| **4** | YL Direct 04 | 11.00 | 2.72 | Direct 3 | 0.34 | 7.94 |
| **5** | YL Direct 05 | 10.20 | 2.19 | Direct 3 & 2 | 0.58 | 7.43 |
| **6** | YL Feeder 01 | 12.50 | 0.00 | - | 0.00 | 12.50 |
| **7** | YL Feeder 02A | 11.00 | 0.00 | Direct 1 | 0.70 | 10.30 |
| **8** | YL Feeder 02B | 3.40 | 0.00 | Feeder 2A | 3.40 | 0.00 |
| | **Total** | **101.37** | **19.70** | | **5.60** | **76.05** |

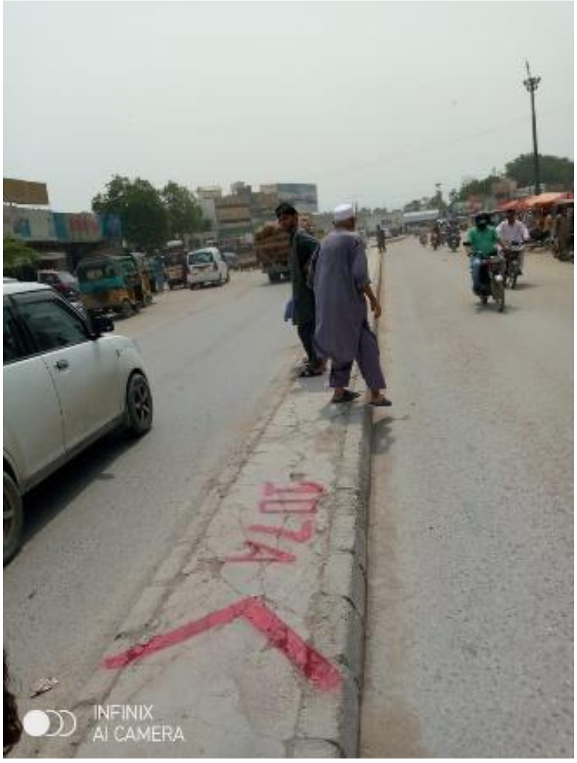


**Figure 3: Reconnaissance survey near Dawood Chowrangi**

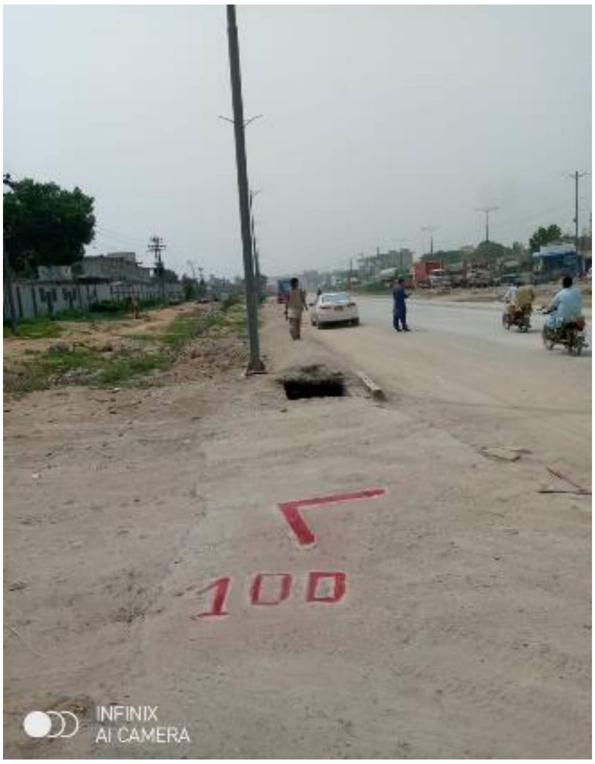


**Figure 4: Reconnaissance survey on 8000 road**

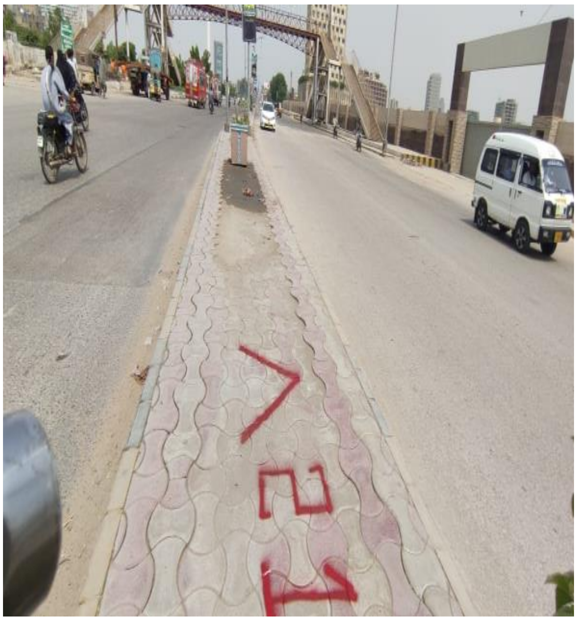


**Figure 5: Reconnaissance survey on Korangi road near CSD**

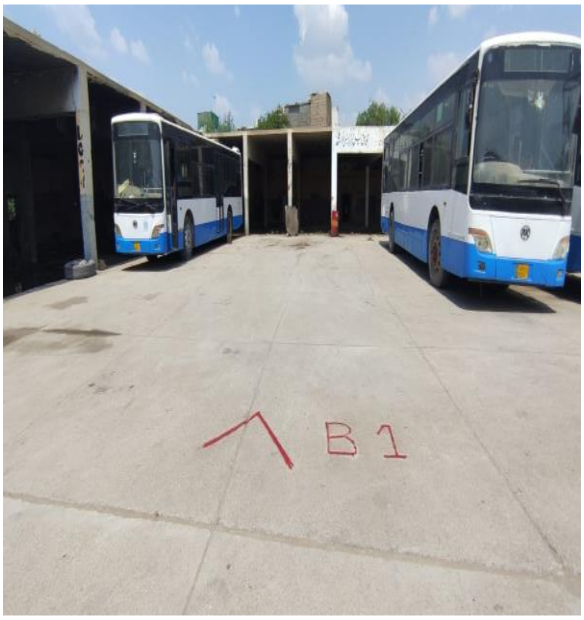
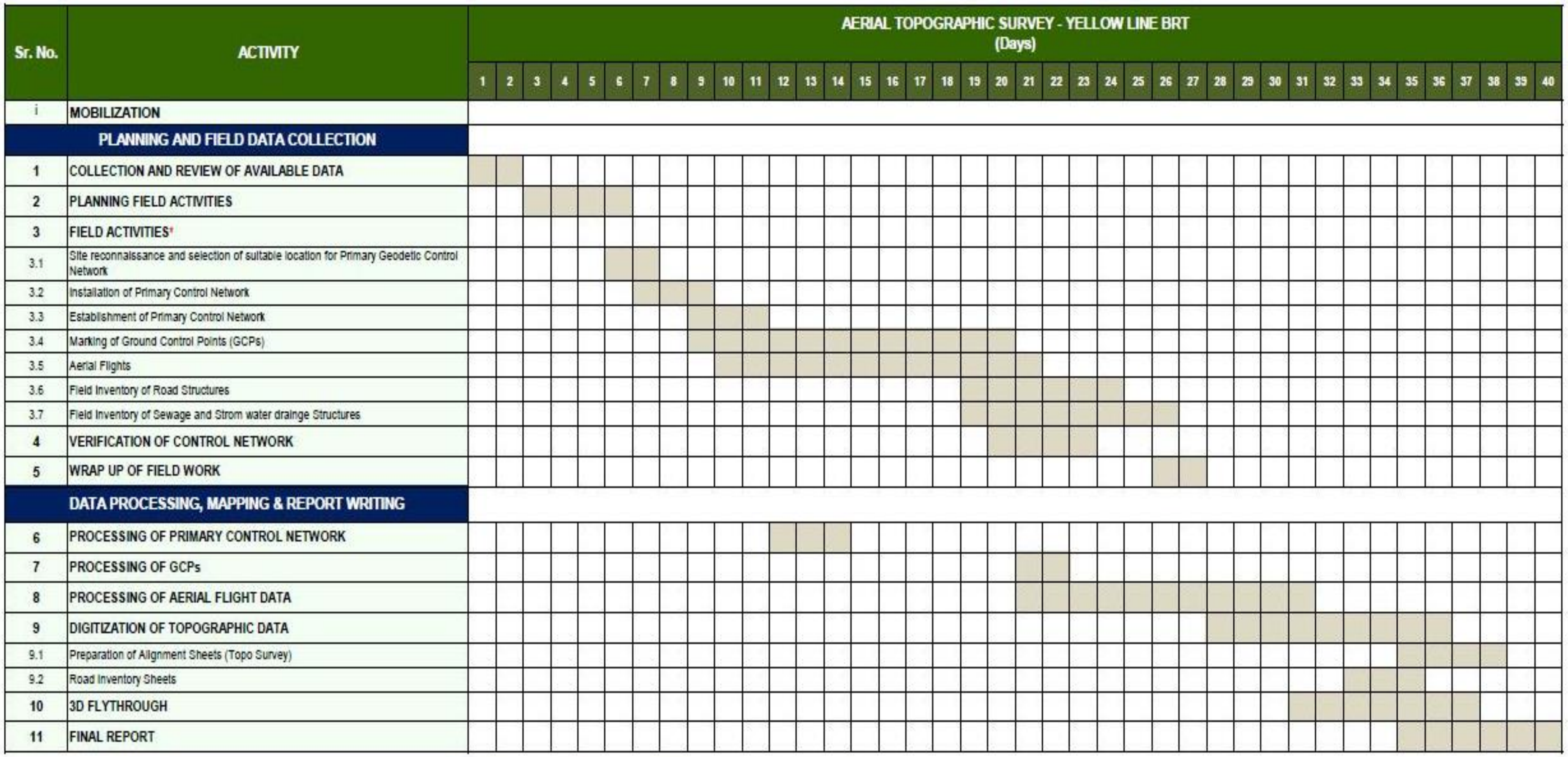


**Figure 6: Reconnaissance survey on Depot (1) near Dawood Chowrang**

## 4.3 SURVEY SCHEDULE

Table 3 below shows the proposed work plan / activity schedule for Topographic survey.

**Table 3: Work Plan / Activity Schedule for Topographic Survey**



| Sr. No. | ACTIVITY | AERIAL TOPOGRAPHIC SURVEY - YELLOW LINE BRT (Days) | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 |
| i | MOBILIZATION | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | **PLANNING AND FIELD DATA COLLECTION** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1 | COLLECTION AND REVIEW OF AVAILABLE DATA | ▨ | ▨ | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 2 | PLANNING FIELD ACTIVITIES | | | ▨ | ▨ | ▨ | ▨ | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 3 | FIELD ACTIVITIES* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 3.1 | Site reconnaissance and selection of suitable location for Primary Geodetic Control Network | | | | | | ▨ | ▨ | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 3.2 | Installation of Primary Control Network | | | | | | | ▨ | ▨ | ▨ | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 3.3 | Establishment of Primary Control Network | | | | | | | | | ▨ | ▨ | ▨ | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 3.4 | Marking of Ground Control Points (GCPs) | | | | | | | | | ▨ | ▨ | ▨ | ▨ | ▨ | ▨ | ▨ | ▨ | ▨ | ▨ | ▨ | ▨ | | | | | | | | | | | | | | | | | | | | |
| 3.5 | Aerial Flights | | | | | | | | | | ▨ | ▨ | ▨ | ▨ | ▨ | ▨ | ▨ | ▨ | ▨ | ▨ | ▨ | ▨ | | | | | | | | | | | | | | | | | | | |
| 3.6 | Field Inventory of Road Structures | | | | | | | | | | | | | | | | | | | ▨ | ▨ | ▨ | ▨ | ▨ | ▨ | | | | | | | | | | | | | | | | |
| 3.7 | Field Inventory of Sewage and Strom water drainge Structures | | | | | | | | | | | | | | | | | | | ▨ | ▨ | ▨ | ▨ | ▨ | ▨ | ▨ | ▨ | | | | | | | | | | | | | | |
| 4 | VERIFICATION OF CONTROL NETWORK | | | | | | | | | | | | | | | | | | | | ▨ | ▨ | ▨ | ▨ | | | | | | | | | | | | | | | | | |
| 5 | WRAP UP OF FIELD WORK | | | | | | | | | | | | | | | | | | | | | | | | | | ▨ | ▨ | | | | | | | | | | | | | |
| | **DATA PROCESSING, MAPPING & REPORT WRITING** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 6 | PROCESSING OF PRIMARY CONTROL NETWORK | | | | | | | | | | | | ▨ | ▨ | ▨ | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 7 | PROCESSING OF GCPs | | | | | | | | | | | | | | | | | | | | | ▨ | ▨ | | | | | | | | | | | | | | | | | | |
| 8 | PROCESSING OF AERIAL FLIGHT DATA | | | | | | | | | | | | | | | | | | | | | ▨ | ▨ | ▨ | ▨ | ▨ | ▨ | ▨ | ▨ | ▨ | ▨ | ▨ | | | | | | | | | |
| 9 | DIGITIZATION OF TOPOGRAPHIC DATA | | | | | | | | | | | | | | | | | | | | | | | | | | | | ▨ | ▨ | ▨ | ▨ | ▨ | ▨ | ▨ | ▨ | ▨ | | | | |
| 9.1 | Preparation of Alignment Sheets (Topo Survey) | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | ▨ | ▨ | ▨ | ▨ | | |
| 9.2 | Road Inventory Sheets | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | ▨ | ▨ | ▨ | | | | | |
| 10 | 3D FLYTHROUGH | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | ▨ | ▨ | ▨ | ▨ | ▨ | ▨ | ▨ | | | |
| 11 | FINAL REPORT | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | ▨ | ▨ | ▨ | ▨ | ▨ | ▨ |

* *The field activities are subject to favorable weather conditions and secure site accessability.*

## 4.4 SURVEY OF PAKISTAN BENCHMARKS

The Survey of Pakistan Benchmarks control network has been identified near Karachi Cantt station. These Benchmarks will act as the base control points for further establishment of the control network within the project area. Figures 7 & 8 show Survey of Pakistan benchmarks at Karachi Cantt and Landhi stations, respectively.

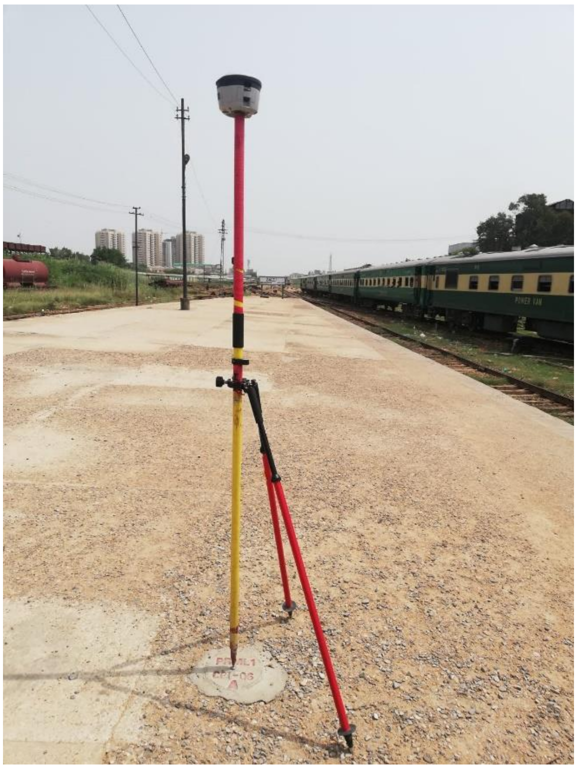


**Figure 7: Survey of Pakistan benchmark in Karachi Cantt Station**

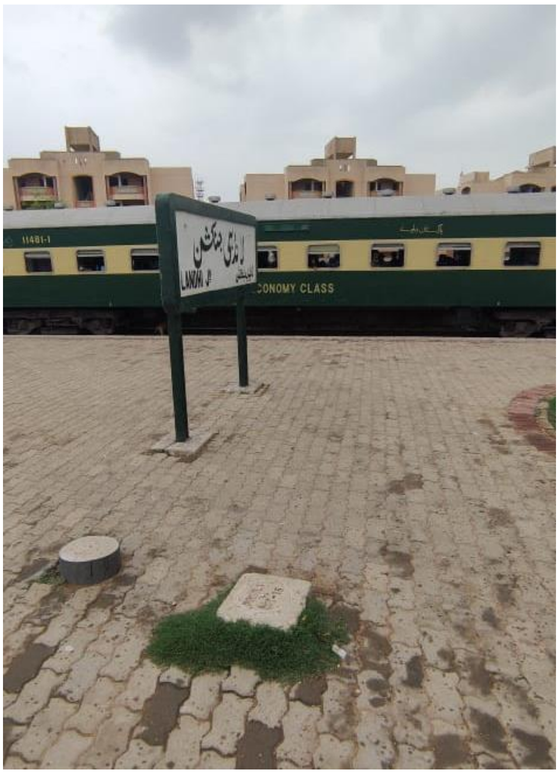


**Figure 8: Survey of Pakistan benchmark in Landhi Station**

## 4.5 ESTABLISHMENT OF BENCHMARKS

This covers the placement of permanent Benchmark (survey control monuments) along the routes for use by the Contractor during the Construction Stage. Monuments will be placed at every 500m intervals and be inter-visible. Details of the x, y and z coordinates for each monument will be reported in the topographic survey report.

## 4.6 DEMARCATION OF CENTERLINE

Centerline staking at the locations including intersections (P.I), beginning and ending of the horizontal curves (P.0 and P.T) will be tied to permanent references points after finalization of the detailed design.

## 4.7. SURVEY METHODOLOGY

Aerial topographic survey technique will be used in this project, which is an advance alternative source of detailed topographic survey. The use of drone survey corroborates with the Consultants' methodology in the Technical Proposal. However, various areas of this project have been designated as no-fly zone for drone cameras because of commercial

/ strategic operations of Jinnah International airport and Faisal Base. Conventional land topographic survey technique will be used in these areas.

## 4.8 AERIAL SURVEY

Arial photogrammetry enables the accurate mapping of 3D coordinates on the ground, using 2D coordinates measured on stereo aerial photographs that see the same points on the ground from two or more different perspectives. The acquisition of high-resolution aerial images using unmanned aerial vehicles (UAVs) to extract topographic information of the Earth's surface is widely being used specially in inaccessible, treacherous, hard terrain and disaster areas.

Applications of photogrammetry in surveying practice include topographic mapping, site planning, and earthwork & volume estimation, and other topographical analysis for command area development project, compilation of digital elevation models (DEM), and image base mapping (Ortho-Photography).

UAVs are equipped with a calibrated digital camera and the autopilot system which capture the images at low altitude. Ground Control Points (GCPs) using GNSS system are required to process the overlapping images to get required results. The images are further processed to obtain the Digital Surface Model (DSM), Digital Terrain Model (DTM) having 10-20cm and Ortho rectified Aerial Image of 3-5cm resolutions.

Figures 9 & 10 show concept of options for topographic survey and hierarchy of aerial topographic survey respectively.

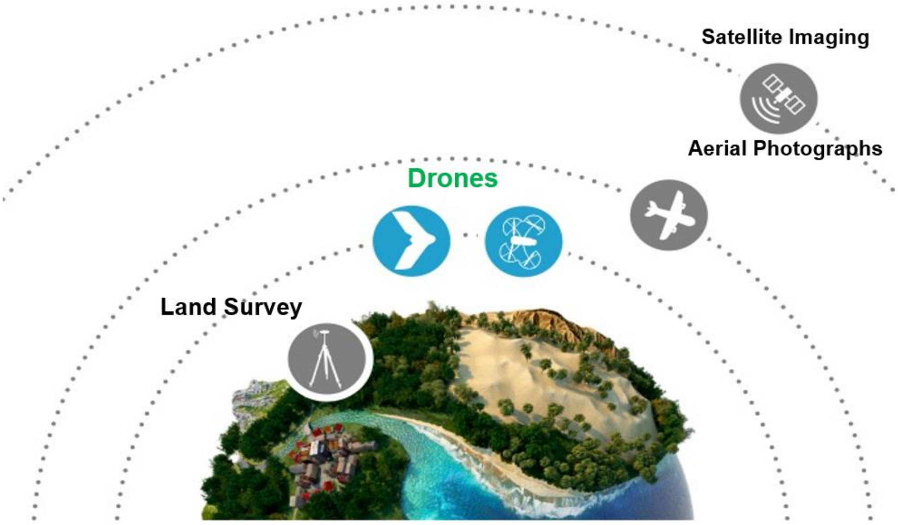


Figure 9: Concept of Options for Topographic Survey.

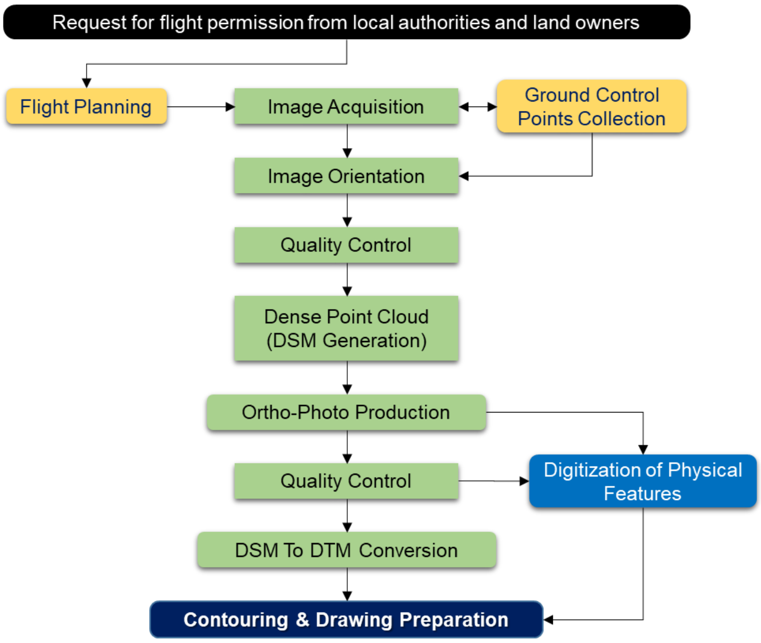

Request for flight permission from local authorities and land owners
Flight Planning
Image Acquisition
Ground Control Points Collection
Image Orientation
Quality Control
Dense Point Cloud (DSM Generation)
Ortho-Photo Production
Quality Control
Digitization of Physical Features
DSM To DTM Conversion
Contouring & Drawing Preparation

**Figure 10: Hierarchy of aerial topographic survey**

## 4.9 LAND SURVEY

The Trimble (R02, R09) and Leica (GS10& GS15) Global Navigation Satellite System (GNSS) instruments will be used having base station and rovers for transfer of the control network from Survey of Pakistan Benchmarks to project area site. Figure 11 shows Trimble base setup.

The observed data will be processed by using the standard Leica Geo office and Trimble Business Centre software. The survey data will be processed in AutoCAD and Eagle Point software for layouts

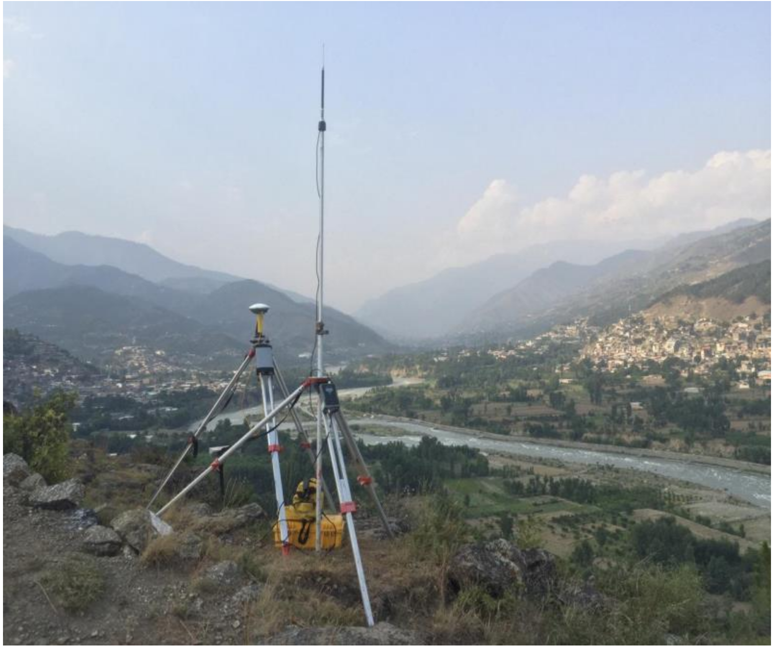


**Figure 11: Base Station setup for cross sectional survey data collection**

# 5. STRUCTURES CONDITION SURVEY OF JAM SADIQ BRIDGE

## 5.1 INTRODUCTION

To carry out the structural investigation and evaluation of the existing condition of Jam Sadiq Bridge, various types of tests and inspections have been planned. Initially, the Consultants will assess the existing condition of the bridge through visual inspection which will then be followed by destructive and non-destructive tests. The Consultants will appoint specialized contractor to conduct the tests for the detailed evaluation of the bridge.

The tests include the following:

- Core Extraction and Compressive Strength Test.
- Rebar Scanning or Ferro scanning
- CAPO Test
- Chloride Content Test of extracted cores
- Rebound Hammer (Schmidt hammer) Test.
- Sulphate content Test of extracted cores
- Concrete Composition Test
- Carbonation Test on extracted cores
- Excavation of Pit for Partial / Limited Exposure of top part of pile / pile cap
- Void Ratio Test

## 5.2 SITE RECONNAISSANCE SURVEY

Various site reconnaissance survey visits have been conducted to assess the field conditions, span access, condition of existing piers, girders, expansion joints, drainage, and pavement condition. Figures 12 and 13 show general views of Jam Sadiq Bridge.

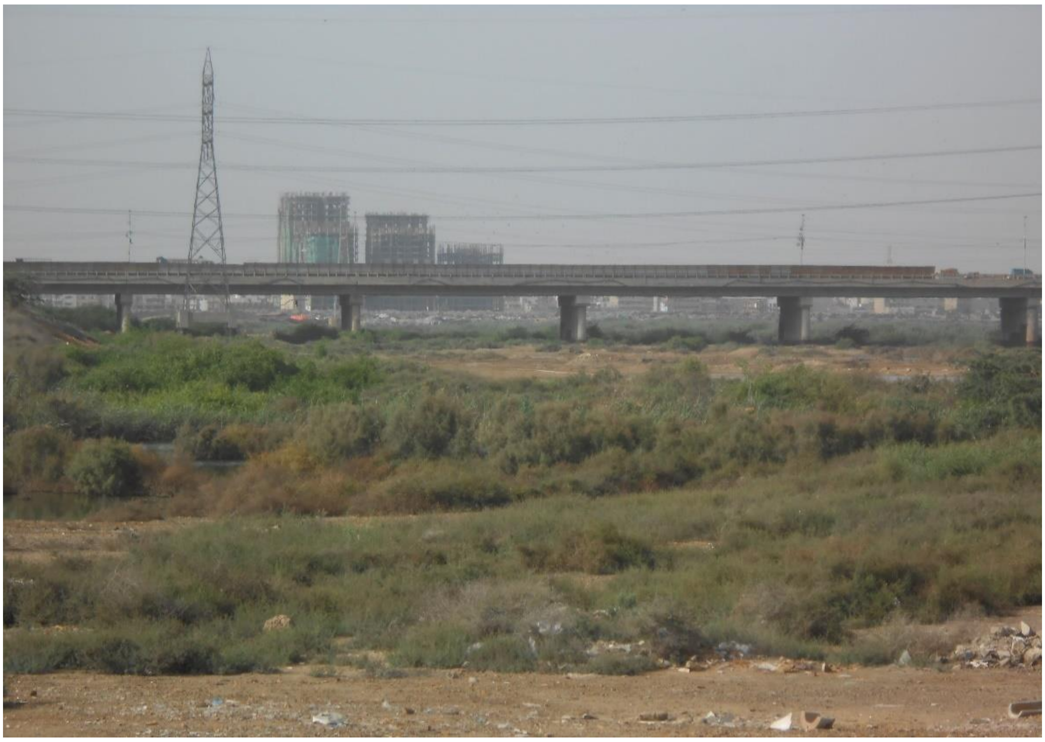


Figure 12: Reconnaissance survey of Jam Sadiq Bridge (from Korangi Causeway side)

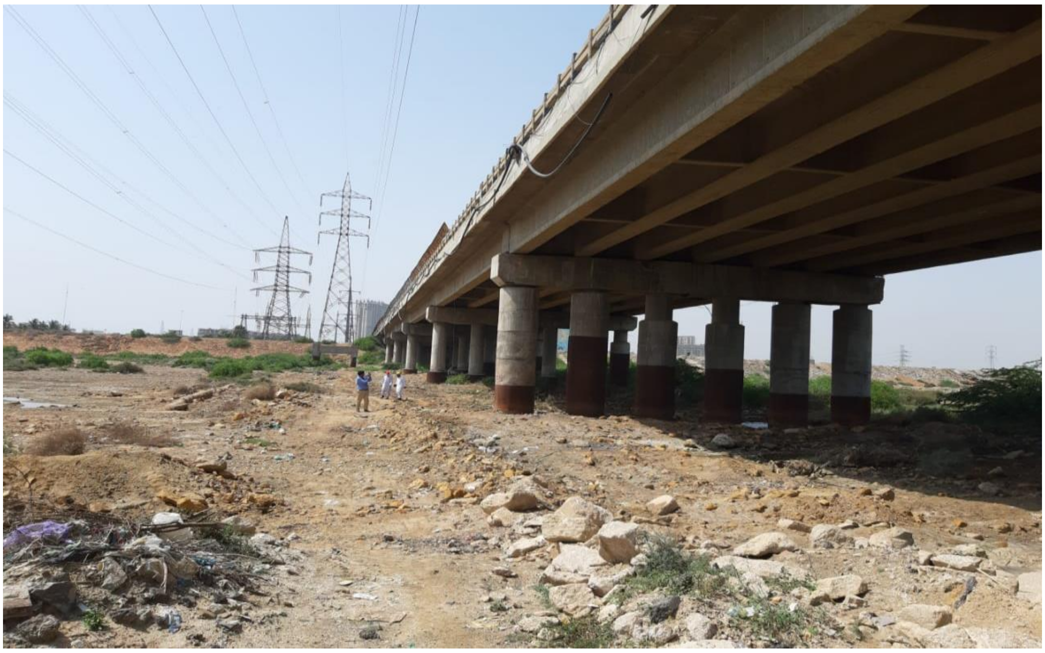


Figure 13: Reconnaissance survey of Jam Sadiq Bridge (Towards KPT Interchange)

## 5.3 CORE EXTRACTION AND COMPRESSIVE STRENGTH TEST

This procedure covers the conditions when doubt exists about the in-place concrete quality due either to low strength test results during construction or signs of distress in the structure. Additionally, this method may also be used to provide strength information on older structures. This method is limited to obtaining, preparing, and testing cores drilled from concrete for length or compressive strength determination.

The test is conducted according to ASTM C42 and ASTM C39. The cored holes shall be immediately closed with non-shrink grout. Steel detector is used during hole drilling to avoid cutting of steel reinforcement.

The specimen will be capped according to Test Method ASTM C 617/C617M-15 Capping Cylindrical Concrete Specimens," prior to testing in compression.

## 5.4 CAPO TEST

This test method provides a pull-out test system for accurate on-site estimates of compressive strength of the outer 25 mm layer. The test is conducted per ASTM C900.

## 5.5 SCHMIDT HAMMER TEST

This test method covers the determination of a rebound number of hardened concrete using spring-driven steel hammer. The test will be conducted according to ASTM C805

Concrete members to be tested will be at least 100 mm [4 in.] thick and fixed within a structure. Areas exhibiting honeycombing, scaling, or high porosity will be avoided.

A test area will be at least 150 mm [6 in.] in diameter. Heavily textured, soft, or surfaces with loose mortar will be ground flat with the abrasive stone. Smooth-formed or troweled surfaces do not have to be ground prior to testing. Surface water will be removed, if present, before testing.

## 5.6 CARBONATION TEST ON EXTRACTED CORES

This test is carried out to determine the depth of concrete affected due to combined attack of atmospheric carbon dioxide and moisture causing a reduction in level of alkalinity of concrete. A spray of phenolphthalein solution will be used as pH indicator of concrete. The change of colour of concrete to pink will indicate that the concrete is in the good health, whereas no change in colour is suggestive of carbonation-affected concrete.

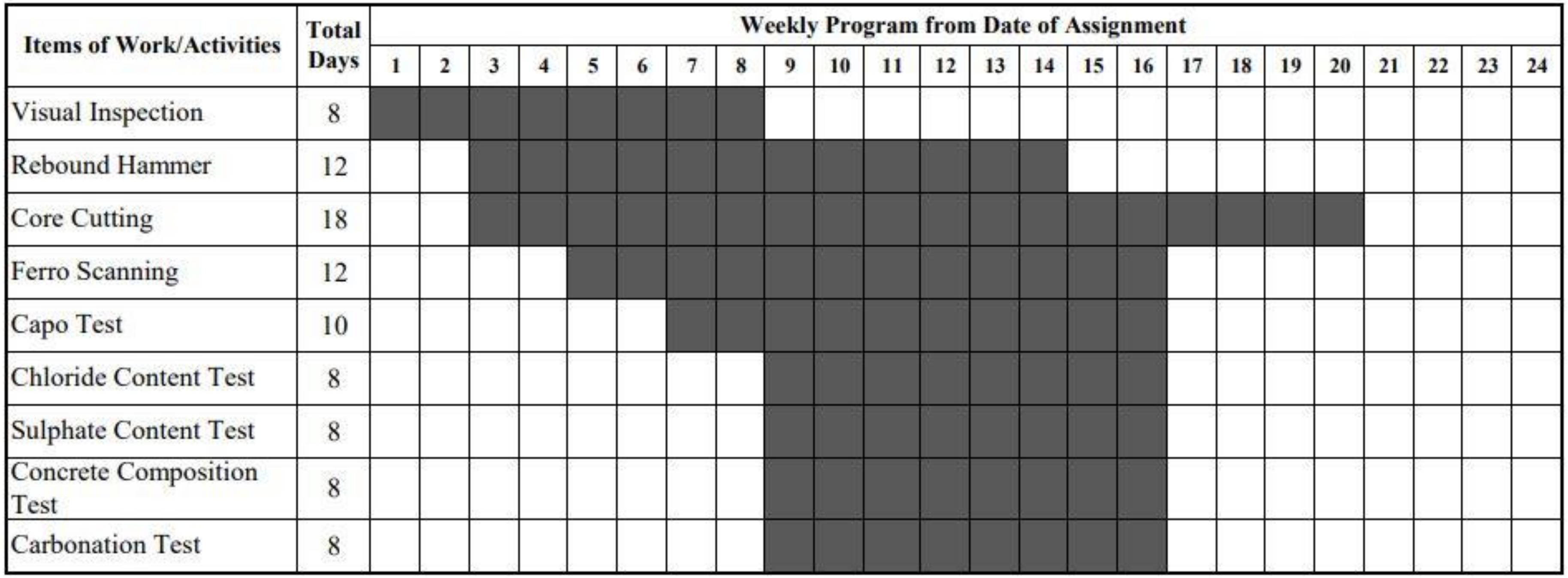
The test will be conducted by drilling a hole on the concrete surface to different depths up to cover concrete thickness, removing dust by air blowing, spraying phenolphthalein with physician’s injection syringe and needle on such freshly drilled broken concrete and observing change in colour. The depth of carbonation will be estimated based on the change in colour profile. The pH value can also be determined by analyzing samples of mortar collected by drilling from the site, dissolving the same in distilled water and thereby titrating in laboratory.

## 5.7 SCHEDULE

The project execution work plan is developed based on project timeline, site reconnaissance survey and stakeholder consultations. Table 4 below shows the proposed work plan / activity schedule.

Necessary permissions to conduct surveys will be required from various stakeholders for which coordination shall be requested from the Client to follow the schedule.

**Table 4: Bridge Inspection and Tests Work Plan / Activity Schedule**



| Items of Work/Activities | Total Days | Weekly Program from Date of Assignment | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 |
| Visual Inspection | 8 | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | | | | | | | | | | | | | | | |
| Rebound Hammer | 12 | | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | | | | | | | | | |
| Core Cutting | 18 | | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | | | |
| Ferro Scanning | 12 | | | | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | | | | | | | |
| Capo Test | 10 | | | | | | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | | | | | | | |
| Chloride Content Test | 8 | | | | | | | | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | | | | | | | |
| Sulphate Content Test | 8 | | | | | | | | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | | | | | | | |
| Concrete Composition Test | 8 | | | | | | | | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | | | | | | | |
| Carbonation Test | 8 | | | | | | | | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | | | | | | | |

# 6. UTILITIES SURVEY

## 6.1 INTRODUCTION

In the city of Karachi, Utility Relocation requires very close coordination with various departments and clearance from the utility companies and the local authority which is Karachi Metropolitan Corporation (KMC). Considering the clearance from various departments/utility agencies, the relocation works will be a challenging task especially considering the strict project timelines.

## 6.2 DATA COLLECTION

The Consultants have shared the Preliminary Design drawings with the various utility agencies, including:

- Sui Southern Gas Company Limited (SSGC)
- K-Electric
- Pakistan Telecommunication Corporation Limited (PTCL)
- National Telecommunication Corporation (NTC)
- Karachi Water & Sewerage Board (KW&SB)
- Private telecom operators
- Pak Arab Refinery (PARCO)
- Pakistan Refinery Limited (PRL)
- National Refinery Limited (NRL)

The shared plans include the utility information provided by various utility agencies at the time of preparation of the Preliminary Design in 2019. The utility agencies have been asked to:

- Verify the accuracy of data provided in the Preliminary Design
- Update any new lines that have been laid since 2019
- Provide information about any future plans along the project.

## 6.3 SITE RECONNAISSANCE SURVEY

Once the utility agencies review their previous information, site visits will be conducted with representatives of utility agencies to mark their respective utility lines on the ground. Utility agencies having facility to locate their lines like SSGS will be asked to verify the same. Furthermore, test/trial pits will also be executed at various locations to verify the utilities in the presence of representatives from respective utility agencies.

The received information will then be marked on the plans and updated information will be shared with the utility agencies for final verification. Once the verification is received, any utility falling under the proposed project and needs to be relocated will be identified, and the utility agency will be requested to provide their relocation plan and cost for the same.

The Client' assistance is needed to maintain close coordination with various utility departments in order to streamline the utility identification / relocation process.

# 7. ASSESSMENT OF EXISTING PAVEMENT

## 7.1 INTRODUCTION

The basic purpose of evaluating the pavement surface condition is to find out the extent, magnitude and severity of distress of various types. Pavement surface condition data is used as one of the indicators to identify the structural and functional deficiencies. Based on this data and other related information, the identification of pavement distress, maintenance treatments and selection of corrective measures will then be planned and designed.

## 7.2 SITE RECONNAISSANCE SURVEY

A pavement visual condition survey has been carried out by the Consultants for the main corridor and off-corridor during the month of October 2021. The initial objective was set to determine the ride quality degree of the different road sections for the main corridor. Different distress types were reported for each zone over the main alignment. This will serve for the upcoming assessment stage to provide a pavement rating degree for each surveyed zone. This rating with the projected field tests (FWD, coring, etc..) will serve to provide clear information of the required rehabilitation/ reconstruction measures.

A preliminary assessment (without any rating calculation for paved sections) revealed that the conditions of asphalt surface are as shown in Figure 14 below.

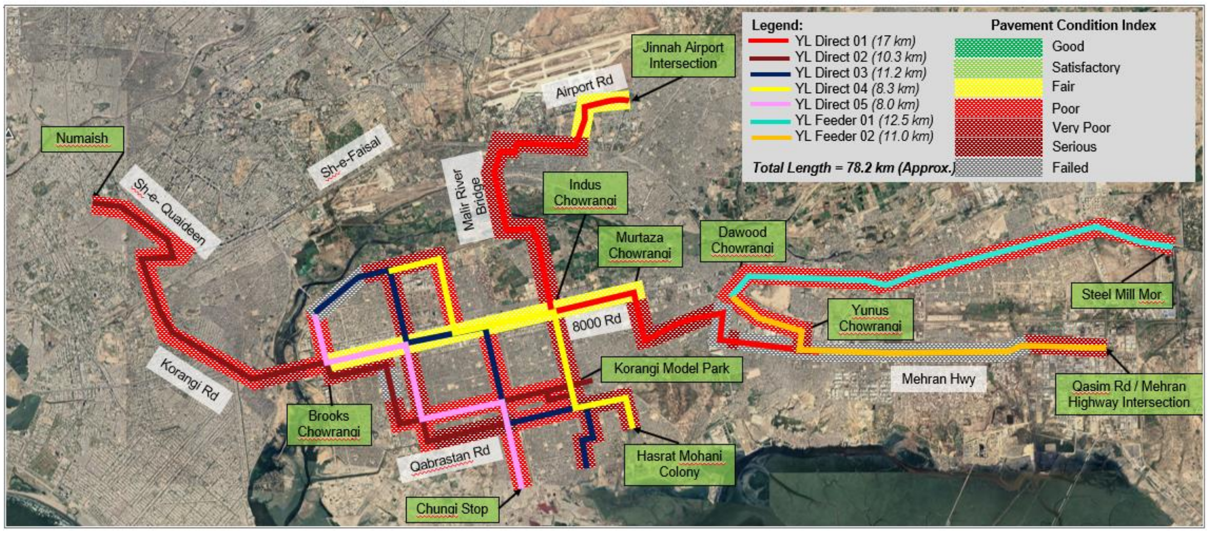


Figure 14: Existing Pavement Status based on Reconnaissance Survey

## 7.3 PAVEMENT ASSESSMENT SURVEY

Based on the site visit observations, the pavement assessment plan is finalized for the proposed development works, and will be carried out at site under the full-time supervision of Consultants' staff through specialized contractor(s), who will provide Falling weight deflectometer (FWD) that can apply a plate load to simulate the tire load of heavy truck.

The proposed pavement assessment survey will comprise the following:

- A total of Eight hundred and Eighty (880) Falling Weight Deflectometer (FWD) tests are required. The locations of the FWD test points are to be considered at 100m interval along the alignment (staggered between the lanes) of the off corridor roads. This interval will be reduced to 50 m along the main corridor. Exceptions will be made for some zones that will not be tested: Bridges such as Jam Sadiq Bridge, underpass structures at Korangi Road at the roundabouts locations eastern of Malir River, and the non-paved areas at Mehran Highway (YL Feeder-2) and Sadiq Akbar Road of YL Direct 03

- The FWD machine will be equipped with brand new Load Cell, Geophones, Infrared Temperature gages for air and pavement surface temperatures, Electronic Distance Measurement device and Control/Data acquisition unit including the microprocessor and laptop.

- The FWD equipment will be calibrated according to the SHRP/LTTP FWD Calibration Protocol or according to the European Standard COST 336. Testing at pavement temperatures above 30ºC is not allowed. Consequently, if the pavement temperature is above the limit, the survey may be required to be carried out during the late afternoon or during the early morning hours.

- A minimum of three drops per point should be performed. If the deflection data looks suspicious, the deflection difference for any sensor is greater than 5% or 5 micron, or the actual test loads are not within 5% of the target load, the operator should rerun the test sequence at the same location.

- FWD Testing will not be conducted near asphalt cracks unless one of the test objectives is to measure load transfer efficiency across the crack.

Prior to starting the works on site, the contractor will be required to provide the following:

- A full description of equipment intended to be used, its mode of operation and method of presentation, back calculation and interpretation of results
- The manufacturer calibration certificate showing that the equipment has been recently calibrated (date of calibration should be in accordance with the manufacturer's requirements)
- Technical qualifications in terms of previous experience in testing and interpreting FWD results for Road Pavement Structures.

Upon the completion of the field test, the contractor will be required to provide all the survey and tests result, including the following:

- FWD test records
- FWD Deflection Results at each tested point

- A record of pavement temperature during FWD testing
- FWD detailed back-calculated Modulii for all pavement layers (asphalt, aggregate base/subbase and subgrade) at each tested point
- The adjusted or corrected back-calculated asphalt concrete modulus. (depending on the mean annual pavement temperature)
- Detailed interpretation of FWD results
- Schedule of contents
- Soft copy of the text, tables and graphics of the report shall be submitted in MS Word, Excel, AutoCAD, or other formats as appropriate and at latest version; The CD shall include:
- Soft copy of the FWD Deflection data (raw data).
- Back calculated FWD in tabular and graphical forms
- A comprehensive report describing the work undertaken with notes on any special situations or conditions relative to the work recommendations for the roads pavement rehabilitation design and construction.